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DESIGN AND DEVELOPMENT OF AN ARCTIC 20,000 GALLON COLLAPSIBLE FUEL TANK (PHASE II)

Final Report for Period

15 August 1980 Through 30 November 1980

by

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Research and Development Command

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Prepared Under Contract DAAK70-79-C-0210 By

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ILC Dover, after successfully developing two candidate coated fabrics for use on the 20,000 gallon Arctic Fuel Tank, built four 3,000 gallon tanks for tests in the Arctic in the winter of 1980-81. Two tanks were built from each successful candidate fabric. ILC designed a new suction stub in order to prevent wicking through the threads of the bolts on the filler/discharge assemblies. Commercial products were found to be acceptable for all other hardware.

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SUMMARY

The purpose of Phase II of this program was to fabricate four prototype 3,000 gallon Arctic Fuel Tanks from the two successful candidate fabrics developed in Phase I. ILC recommended, and was given subsequent approval, to fabricate two tanks from each of the two fabrics.

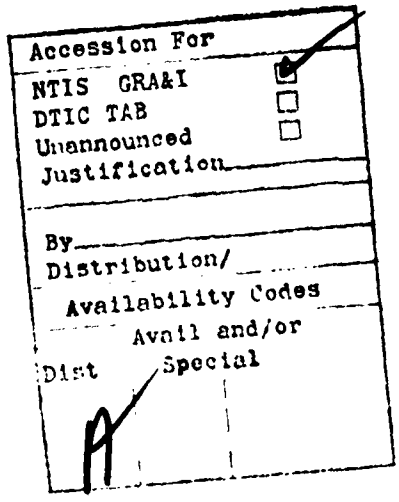
The handle, chafing patch, suction stub and other designs developed during Phase I, along with commercially available hardware, were incorporated into the fabricated tanks. ILC conducted seam testing to determine the optimum seam. The ultimate seam selected was a heat-sealed, butted and taped seam using a base fabric outer tape and a Tuftane 310 inner tape.

The adhesive selected for bonding handles, load patches, and for field repair is a solvent based (THF) adhesive which emits toxic fumes. As a small quantity of the toxic adhesive is included in the repair kit, a gas mask and rubber gloves were provided with each kit to protect personnel during repairs.

The four prototype tanks were shipped in November, 1980 for Army testing under Arctic conditions. ILC recommends that, upon completion of Arctic testing, the tanks be subjected to further testing under various global climactic conditions and evaluated for universal POL use. ILC further recommends the V84-8-1 material be evaluated for compatability with potable water, with the goal of obtaining a truly universal tank.

PREFACE

This report delineates work done under Phase II of Contract DAAK70-79-C-0210 for the U.S. Army Mobility Equipment Research and Development Command to coated fabrics, hardware, and assembly techniques for fabrication of the 3,000 gallon prototypes of 20,000 gallon fuel storage tanks capable of Arctic servicibility to -60°F. Previous efforts have resulted in acceptability at -25°F to -30°F. This report recognizes the assistance of Mr. Dan McCardy of Evertite for his invaluable assistance.



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1.0 INTRODUCTION

Low temperature serviceability of currently-used collapsible fuel storage tanks is limited to -25°F or -30°F. Effort was initiated by MERADCOM to extend service life to -60°F through development of suitable coated fabrics, seaming, bonding and fabrication techniques. Results of this work would then be applied to fabrication of 3,000 gallon prototype tanks for further test and evaluation.

ILC Dover was awarded contract DAAK70-79-C-0210 to accomplish the aforementioned tasks. ILC has produced two candidate coated fabrics and validated both heat sealed and adhesive seams; both with and without a film used to limit wicking. ILC has validated its bonding techniques to aluminum fittings and developed a leak proof suction stub. Also, a redesigned handle structure exceeds the pull requirement by 780 pounds. ILC then produced two tanks of each material. Results of Phase II efforts are presented in this report.

2.0 TANK CONSTRUCTION PROCEDURE DISCUSSION

The four 3,000 gallon tanks were numbered 0001 through 0004. Tanks #0001 and 0002 were made from the V-84-8-1 material. Tank #0003 and 0004 were made from V-84-29-1.

2.1 SEAMS

The seam that was used on tanks #0001 and 0002 is shown in Figure 1. This seam was tested during fabrication and met all the requirements specified by contract. Upon going to the V84-29 material of tank #0003, seam samples began "pulling out". "Pulling out" is the term used for a type of failure for a one inch by six inch tensile test specimen in which the yarns of the base fabric (which run lengthwise on the specimen) pull out from under the seam, leaving the elastomer attached to the seam. This is usually an indication that the width of overlap of the tape is not adequate. This dimension was increased so that the tape width was then 1-3/4 inches wide (See Figure 2) for tank #0003.

Throughout the manufacture of tank #0003, the Tuftane film was reluctant to seal due to the dissimilar melting temperatures of Tuftane and the urethane. Although the seams on tank #0003 met specifications, the manufacturing people doing the sealing found the seam hard to work with. The decision was then made for tank #0004 to be made with the interior tape of the same material from which the tank is made (Figure 3).

During fabrication of the tanks, a minimum of three seam samples a day were made to insure that the seam met specifications - one in the morning when work began, one after lunch and one at day's end.

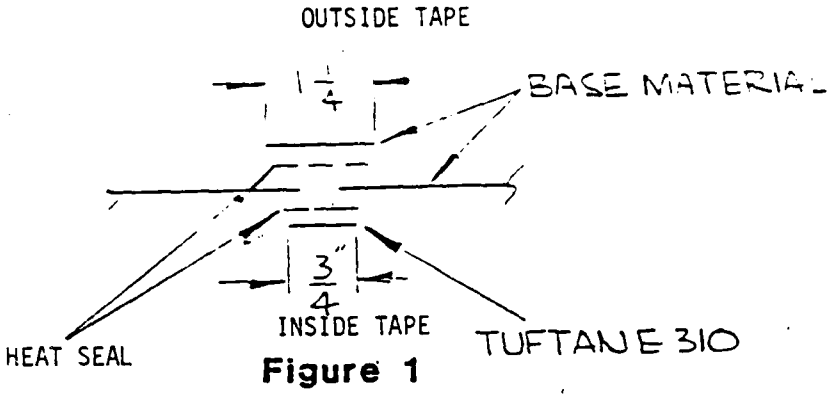

Figure 1

TANK 0001 & 0002 SEAM

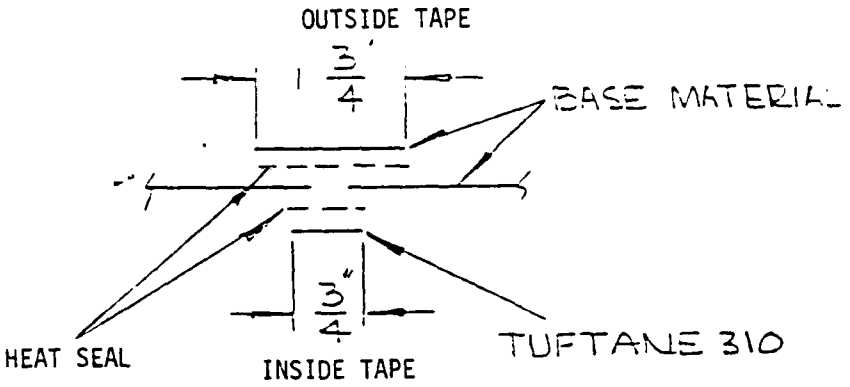

Figure 2

TANK 0003 SEAM

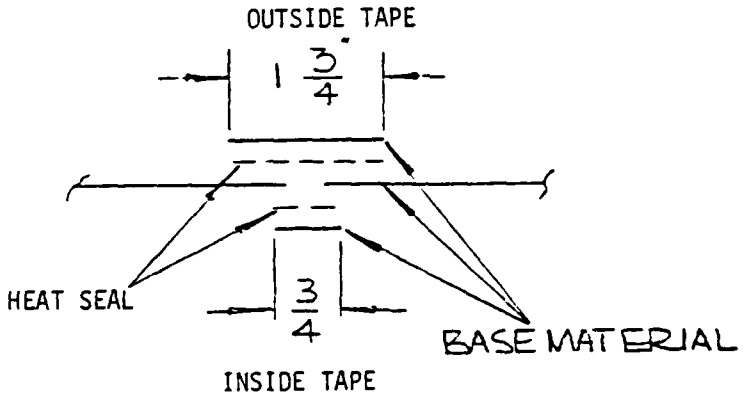

Figure 3

TANK 0004 SEAM

2.2 SUBASSEMBLIES

2.2.1 Handle

The handle assembly was fabricated as shown in Figure 4 using the Bostik 7133 adhesive polyester webbing, size FF thread, and tank material. The first step in assembly is to sew two 24 inch lengths of 6,000 pound tensile polyester webbing together using size FF polyester thread using a box stitch (5-6 stitches per inch). The box should end 3 inches from either end (See Figure 5) and have an extra row of stitches along each end of the box. The ends of the webbing are then inserted through the outer patch made from the tank material. The two circular inner patches are then cemented over the slits insuring the two webbing ends are at a 180^{0} angle to each other. A box stitch is then sewn in through the large patch, the webbing and the inner patch. An extra row of stitches is sewn along the side of the box facing the slit. At final assembly, the handle is then cemented to the tank.

2.2.2 Label

The label is made by impressing a 20 mil piece of Tuftane 310 with an offset printing plate which is laid out as shown in Figure 6. To make the letters stand out, a piece of nylon cloth is placed behind the Tuftane at the time of impression. Once the label has been made and attached to the tank at final assembly, the pertinent information is stamped in white ink on the tank.

2.3 TANK CONSTRUCTION

The first step in construction of the 3,000 gallon tank was to form the two end panels. This is done by taking one material width (50 inches wide) and marking the centerline. Once this line is marked, an arc with an eight inch radius is drawn and cut as shown in Figure 7. This piece is then folded over on itself and Side A sealed to Side B and Side C to Side D using the heat seal (RF) machine and the seam listed in Paragraph 2.1.

The next step is to cut the two center section panels to the proper length (twice the tank length) and prepare these panels for attachment of the hardware and chafing patches. The access door/vent/drain fitting hardware locations were

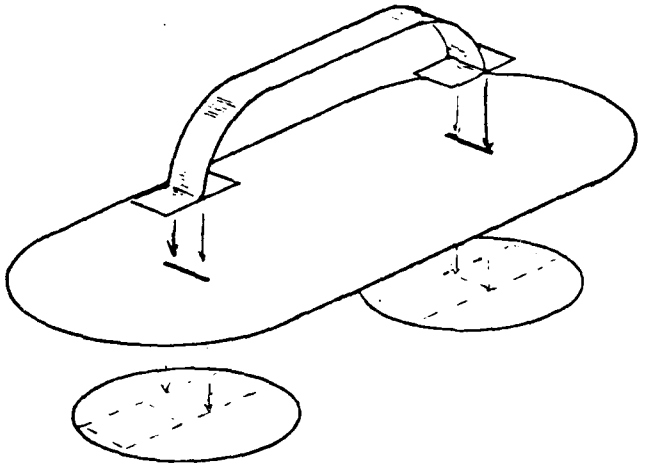

Figure 4

HANDLE ASSEMBLY

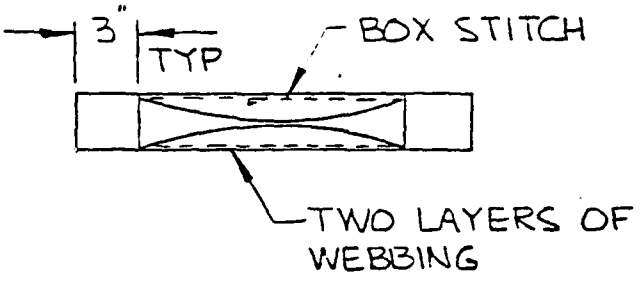

Figure 5

HANDLE WEBBING STITCHING

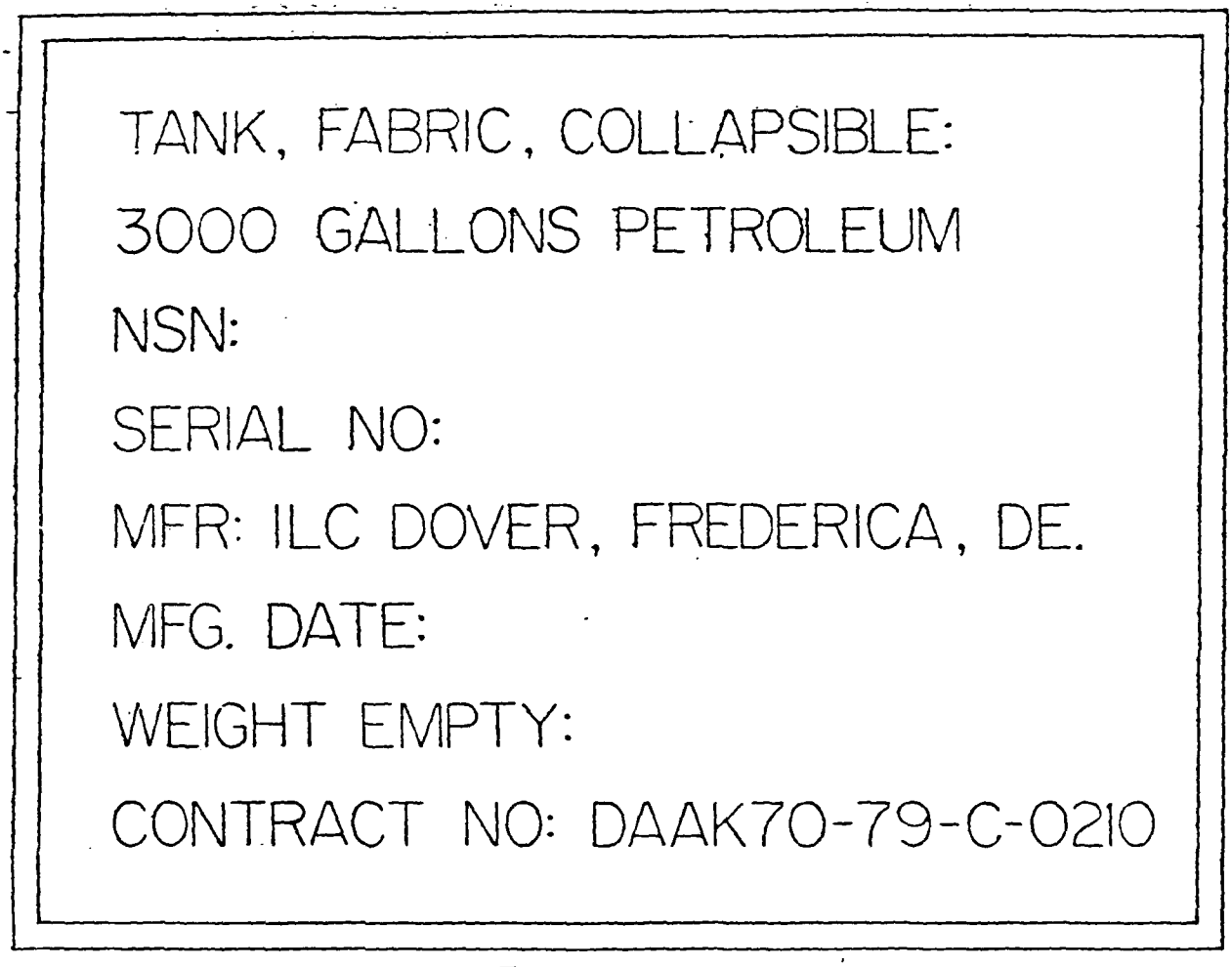

Figure 6

LABEL
ARCTIC FUEL TANK

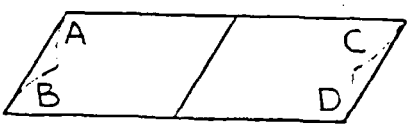

Figure 7

END PANEL MARKING

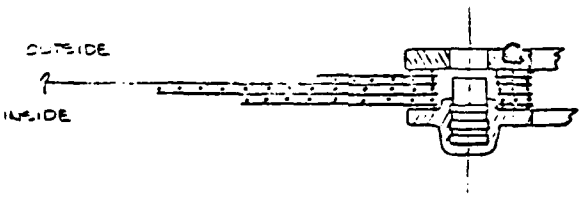

Figure 8

BONDED FITTING ASSEMBLY

prepared the same way. That is, on the side facing the inside of the tank, a patch was adhered to the center panel that extended three inches outside where the fitting would be. A second patch was then adhered over the first that extended two inches outside the hardware. A third patch was adhered to the side of the center panel that would face the outside of the tank and extended one inch outside the center panel. All these reinforcement patches were adhered with Bostik 7133. The final step in installation of the hardware was to adhere the hardware to the plied up area (See Figure 8) using Versilok 201. The chafing patches were then adhered (using Bostik 7133) to areas of the center panels that, when the tank was finished, would be opposite the hardware. The appropriate center panels were then heat sealed to their respective end panels as shown in Figure 9. Once done, the two resulting sections were then seamed together as in Figure 10. The closure seam was the bottom transverse seam (shown at Area A of Figure 10) and that seam was heat sealed . The eight handles and label were then adhered to the tank using Bostik 7133. All heat sealing was done with RF heat sealing machines in areas which must be air conditioned with humidity no greater than 60%.

2.4 ADHESIVES

Two adhesives each were chosen for bonding urethane-to-urethane and urethane-to-aluminum. The adhesive chosen for bonding urethane-to-urethane was the Bostik 7133. The reason was its superior performance after 14 days in immersion at 160°F in distilled water and reference Fuel D. Of the eight adhesives that were tried, Bostik 7133 was the only adhesive that would take the coating off the base fabric. The adhesive is a urethane solvent based adhesive in which the solvent is THF (tetrahydrafuran). The fumes of the solvent are toxic and flammable and extreme care must be taken when using the adhesive. The adhesive was to be applied as follows:

1. Scuff the area to be adhered with emery paper.
2. Apply a single coat with a brush of adhesive (Bostik 7133) to each piece of material that is to be bonded together and allow to dry.
3. Apply a second coat of Bostik 7133 as in Step 2 above and allow to dry.

4. Activate the adhesive by dabbing a cheese cloth in THF and briefly wiping the area of the material with adhesive on it.
5. Immediately after activating the adhesive with THF, put the two pieces of material that are to be joined together and, using a roller, roll over the affected material to insure good bond and eliminate air bubbles.

The adhesive chosen for bonding urethane to aluminum is the Versilok #201 with Accelerator #4 (Hughson Chemicals Company). Neither of these adhesives is toxic, but the Accelerator #4 is mildly corrosive and care should be taken in its storage. This adhesive should be applied as follows:

1. Dry hone the area to be adhered on the metal fitting and scuff the coated fabric area with emery paper.
2. Apply one coat of accelerator #4 on the aluminum piece to be bonded.
3. Apply onecoat of Versilok 201 to urethane material with brush provided.
4. Immediately join urethane material to aluminum fixture and clamp them either by using vise grips or C-clamps.
5. Leave clamped for approximately one hour.

Both adhesives should be applied in the $50^{o}F$ to $80^{o}F$ temperature range and no greater than 60% humidity.

2.5 HARDWARE

The hardware listed along with its supplier, in Table I was provided and shipped with each tank, Figure 11, 12 and 13 show each of the three major subassemblies and how they are put together. Figure 14 shows each of the subassemblies' placement on the tank.

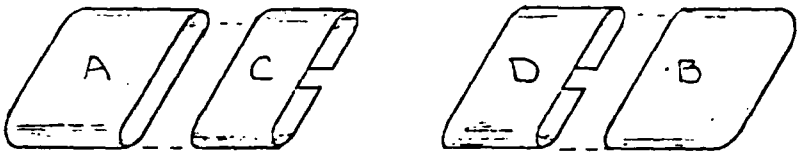

Figure 9

END PANEL-CENTER SECTION ASSEBLY

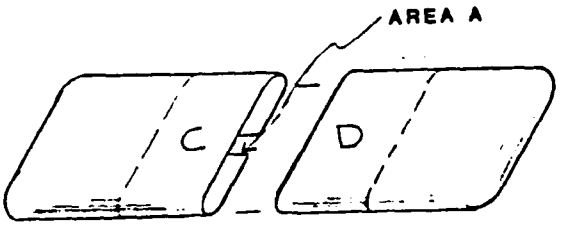

Figure 10

TANK HALF ASSEMBLY

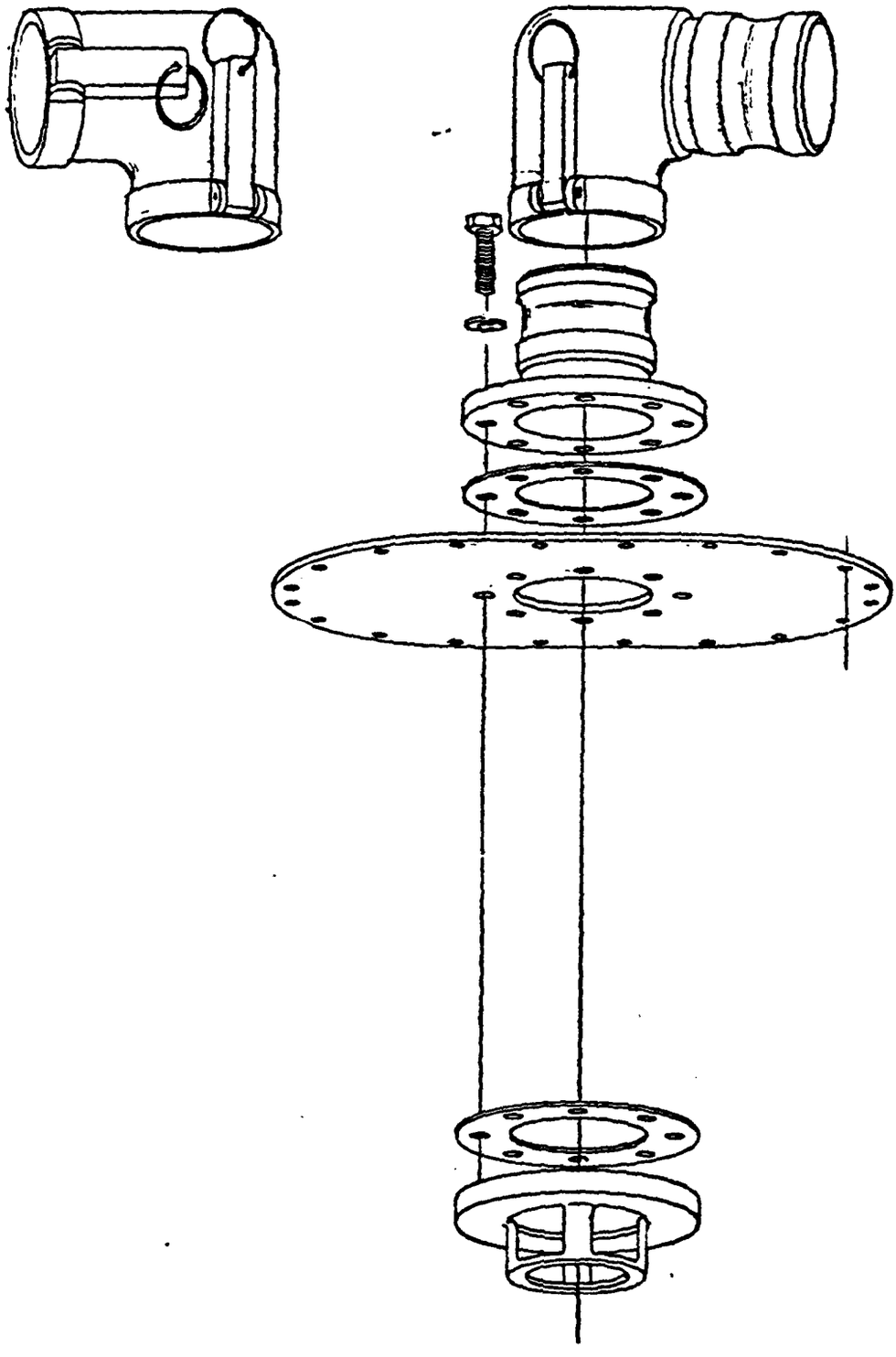

Figure 11
FILLER/DISCHARGE ASSEMBLY
ARCTIC FUEL TANK

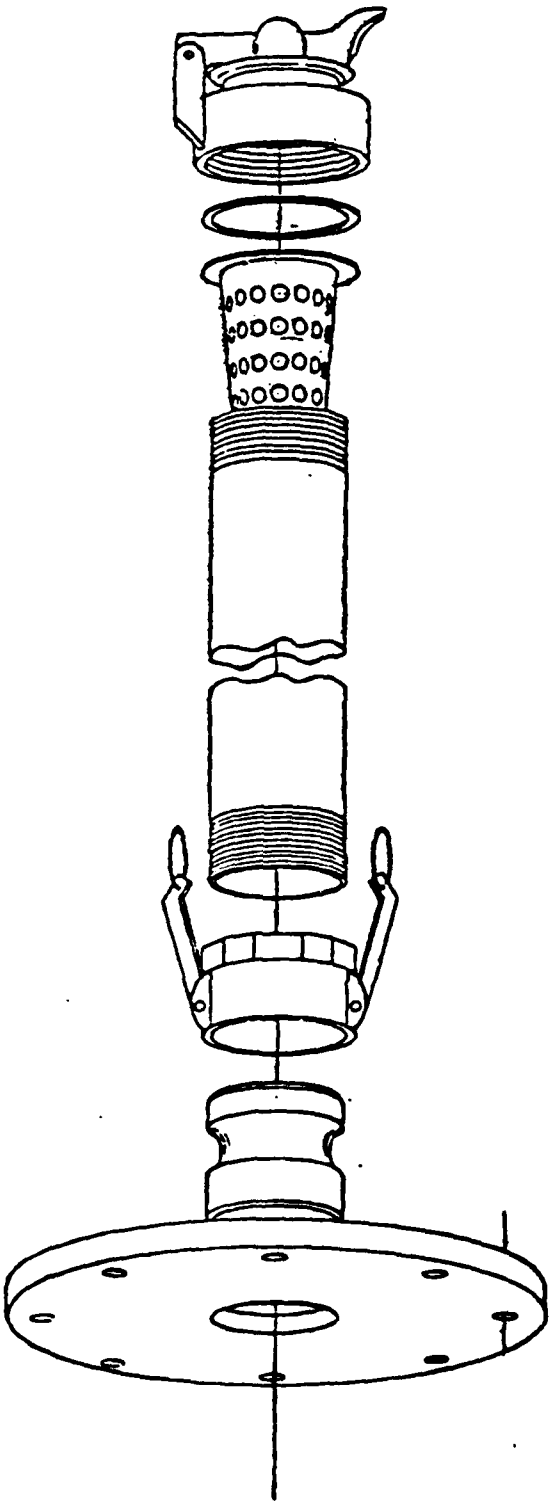

Figure 12

VENT FITTING ASSEMBLY
ARCTIC FUEL TANK

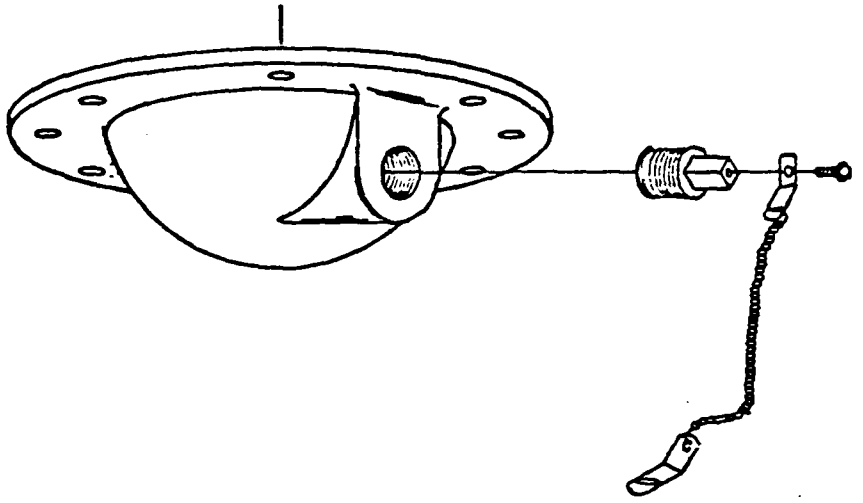

Figure 13

DRAIN FITTING ASSEMBLY
ARCTIC FUEL TANK

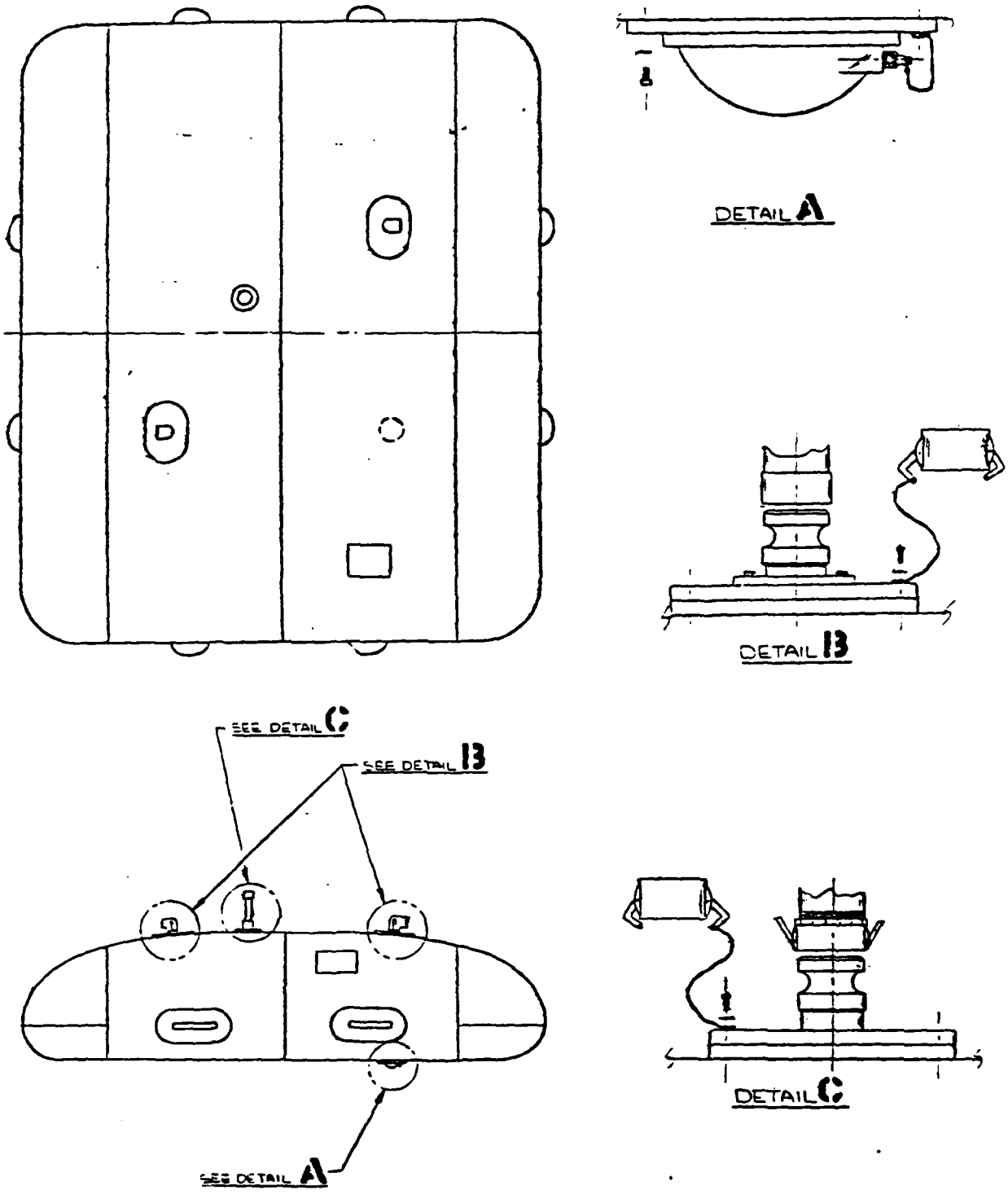

Figure 14

ARCTIC FUEL TANK ASSEMBLY

2.6 EMERGENCY REPAIR KIT

Specifications required that the appropriate clamps, wooden plugs, gaskets, and O-rings be included in the emergency repair kit. The two adhesives that bonded coated fabric to coated fabric and coated fabric to aluminum were also included, along with the procedures for their use. Due to the toxicity of the adhesive used to bond coated fabric to coated fabric (Bostik 7133) a gas mask and butyl gloves were also included. The complete listing of the repair kit components is shown in Table I.

2.7 AIR LEAKAGE TEST

An air leakage test was done in accordance with Paragraph 4.6.2 of MIL-T-82123A (MC) on all four tanks as required by contract. Tanks 0001, 0002, 0003 and 0004 successfully passed this test.

2.8 WATER LEAKAGE TEST

Tank 0001 was filled with approximately 3,000 gallons and let stand for seven days to check for long term leakage. At the end of that period, there was no significant leakage.

3.0 CONCLUSIONS

Phase II of contract DAAK70-79-C-0210 resulted in three major conclusions. First, either of the materials chosen as pre-production candidates can be manufactured in a production environment with no significant difficulty. Based upon the experience with the 3,000 gallon Arctic tank, it can be concluded that ILC can produce a 20,000 gallon Arctic tank in the quantities necessary for the U.S. Army. It should also be concluded that when using Estane 5708,(although a base fabric tape may be used), while the tank is used in the Arctic, Tuftane 310 should be used as the inner tapes because of its resistance to fuels. The Estane 5714 should be manufactured with a base fabric tape as the inner tape and that tape should then be edgelocked. If either material is used in tanks to be tested in a high humidity environment, the inner tape should be made from the base material and then edgelocked.

4.0 RECOMMENDATIONS

ILC recommends that the four 3000 gallon Arctic tanks be tested in the Arctic. ILC also recommends that in order to obtain cost savings in having a universal tank that two tanks should be fabricated and tested in the tropics, (one from each pre-production material). It is interesting to note that the Estane 5708 is very similar to an FDA approved polyurethane. Therefore, to do a complete investigation into the universality of this material, ILC suggests that this material be tested to obtain FDA approval. The potential cost savings to the Army in terms of logistics and procurement would be enormous.

ILC also recommends that further investigation be done to find a less toxic adhesive that will provide the bond strength that the Bostik 7133 currently provides. Continuing work done on Contract DAAK70-79-C-0211, "Design and Development of 7,000 Barrel Collapsible Fabric Fuel Storage Tank", has yielded one possible, less toxic, alternative to this problem.

ILC also recommends that the performance of redesigned suction stub be evaluated by the Army. If this design proves beneficial by use in the field, ILC recommends standardization of all suction stubs to conform to the ILC design.

TABLE I HARDWARE PARTS LIST

I. FILLER/DISCHARGE ASSEMBLY

PART	MFG. PART NUMBER	MANUFACTURER
Access Door Fitting Compression Type	13X19-1 13X19-2	Cast-Rite
Suction Stub	0056-24044-01	ILC
MS9021-383, Style "O" Ring, Fluorosilicone	TH1047-383	DBR Distributing
Oval Closure Plate	1836	Cast-Rite
Gasket, Cork	CP61-0017	SAS Gasket Supply
MS27023-17, Coupling Half Flanged	MS327023-17	Evertite
Elbow, Female to Male 4"	81718/653-4	OPW
MS27028-17 Dust Cap	MS27027-17	Evertite
MS90725-61, Hex Head Cap Screw, .375-16		Century Fastener
MS90725-7, Hex Head Cap Screw,	MS90725-7	Century Fastener
MS27183-10, Flat Round Washer	MS27183-10	Century Fastener
MS35338-46, Lock Washer	MS35338-46	Century Fastener
Elbow, Female to Female, 4"	81718/633-KB	OPW
MS27030-9 Style Gasket, Fluorosilicone	CP61-0014	Unirubber

II. DRAIN FITTING ASSEMBLY

Vent and Drain Fitting Compression Type	600-8-3 600-8-4	Cast-Rite
Drain Fitting	X1184	Cast-Rite
Plug and Chain	CP24-0057	ILC
MS29513-250, Style "O" Ring Gasket, Fluorosilicone	TH1047-250	Unirubber
MS90725-7, Hex Head Cap Screw, .25-20	MS90725-7	Century Fastener
MS27183-10, Flat Washer	MS27183-10	Century Fastener

III. VENT FITTING ASSEMBLY

PART	MFG. PART NUMBER	MANUFACTURER
Vent and Drain Fitting Compression Type		Cast-Rite
MS29513-250, "O" Ring Gasket, Fluorosilicone	TH1047-250	DBR
MS27183-10, Flat Washer	MS27183-10	Century Fastener
MS90725-7, Hex Head Cap Screw	MS90725-7	Century Fastener
Coupling, Male	0056-24064-01	ILC
Coupling, Female	MS27024-11	Evertite
MS27028-11, Dust Cap	MS27028-11	Evertite
Pipe	CP24-0056	ILC
Flame Arrestor and Relief Cap with Gasket	EX1333-2	Protecto-Seal
MS27030-6, Style Gasket Fluorosilicone	CP61-0013	Unirubber

IV. ACCESSORIES

8 ft. length hose (MIL-H-370, Type I)	CP24-0015	Continental Rubber
1/2 inch rising stem gate value (WW-V-54, Type 11, Class A)	CP24-0018	Speakman
10 ft. length hose (MIL-H-370, Type II Size 9, Class 1, Style A)	CP24-0016	Continental Rubber
Flanged Gate Valve with Flanged Flanged Gaskets, MIL-U-58039)	#676FR	OPW
MS27023-17 Coupling	MS27023-17	Evertite
MS27027-17 Coupling	MS27027-17	Evertite
MS27028-17 Cap	MS27028-17	Evertite
MS27029-17 Plug	MS27029-17	Evertite

V. EMERGENCY REPAIR ITEMS

Repair Kit and Repair Kit Componenets		P.M. Manufacturing Bogert and Hopper, ILC

O-Ring, MS 9021-383	TH1047-383	DBR
O-Ring, MS 29513-250	TH1047-250	DBR
Gasket, quick-disconnect coupling, MS 27030-6	CP61-0013	DBR Unirubber
Gasket, quick disconnect coupling MS27030-9	CP61-0024 CP61-0014	 Unirubber
Gasket, 4-inch flange, cork		Unirubber
Gas Mask	448975	MSA
Gloves, Butyl	CP10-0088	Norton Co.

APPENDIX "A"

Continental Rubber
2000 Liberty St.
Erie, Pa. 16512

Bostik
103 Happer Avenue
Hawthorne, N.J. 07506

Hughson Chemicals
2000 W. Grandview Blvd.
Erie, Pa. 16512

Century Fastener
50-20 Ireland St.
Elmhurst, N.J. 11379

Astrux Co.
2937 W. 25th. St.
Cleveland, Ohio 44113

DBR Distributing Co.
83 North Main St.
Yardley, Pa. 19067

MSA
36 Great Valley Parkway
Malvern, Pa. 19355

SAS Gasket and Supply Co.
275 Adams Blvd.
Farmingdale, N.Y. 11735

Protecto Seal Co.
227 Foster Ave.
Bensenville, Ill. 60106

PM Manufacturing
P.O. Box K
Eaton Park, Fla. 33840

Bogert & Hopper, Inc.
23 W. John St.
Hicksville, N.Y. 11801

Speakman
42 Salisbury
Dover, Del. 19901

B.F. Goodrich
500 S. Main St.
Akron, Ohio 44318

OPW
9393 Princeton Glendale Rd
P.O. Box 40240
Cincinnati, Ohio 45240

Evertite
254 W. 54th.
N.Y., N.Y. 10019

Cast-Rite Corp.
515 East Airline Way
Gardena, Ca. 90248

Norton Co.
P.O. Box 70729
Charleston, S. C. 29405

Analytical Chemical Labs
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Elk Grove, IL 60007

Unirubber, Inc.
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